NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE 2018

LOW-SPEED INVESTIGATION OF A THIN, FAIRED, DOUBLE-WEDGE AIRFOIL SECTION WITH NOSE FLAPS OF VARIOUS CHORDS

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SUMMARY

A thin, faired, double-wedge airfoil section was investigated with plain nose flaps having chords equal to 12, 16, 20, and 25 percent of the airfoil chord. Section lift, drag, and pitching-moment data were obtained at a Reynolds number of 5.8 million and a Mach number of 0.17.

A greater positive shift in the angle of attack for zero lift and more negative pitching moments resulted from increased chord of the nose flap. Little effect of nose-flap chord on the maximum lift was found. Increased chord of the nose flap produced the least drag at high lift coefficients.

INTRODUCTION

Although thin, sharp-edged airfoil sections offer considerable promise for certain supersonic aircraft, the low maximum lift and extreme variation of drag with lift, characteristic of thin sections at low speeds, have reduced the attractiveness of such sections for piloted aircraft. Several low-speed investigations have indicated the benefit of nose flaps in improving the maximum lift and in reducing the drag at high lift coefficients. Such benefits were shown in reference 1, wherein the results obtained for a thin, faired, double-wedge airfoil with a 16-percent-chord nose flap were presented.

Most of the low-speed investigations of sharp-edged airfoils that have been undertaken to date have been primarily concerned with one combination of airfoil and nose flap; consequently, there are available few systematic results from which the effects of variation of the nose-flap chord can be assessed. For this reason, it was thought desirable to extend the investigation reported in reference 1 to include variation of nose-flap chord. In this report, the force and moment characteristics of the faired, double-wedge airfoil with 12-, 16-, 20-, and 25-percent-chord nose flaps are presented. The investigation was conducted in the Ames 7- by 10-foot wind tunnel No. 1.

NOTATION

The results are presented in the form of standard NACA coefficients which are defined as follows:

c_{d_o} section profile-drag coefficient $\left(\frac{D}{qc}\right)$

c_l section lift coefficient $\left(\frac{L}{qc}\right)$

c_m section pitching-moment coefficient, referred to the quarter-chord point $\left(\frac{M}{qc^2}\right)$

c airfoil chord, feet

D drag per unit span, pounds per foot

L lift per unit span, pounds per foot

M pitching moment per unit span, pound-feet per foot

q free-stream dynamic pressure, pounds per square foot

α_o section angle of attack, degrees

MODEL AND TESTS

The model used in this investigation was the one that is described in reference 1. For these tests, additional flaps of 12- and 20-percent chord were constructed; in order that the 25-percent-chord trailing-edge flap could be investigated as a nose flap, the model was reversed in the wind tunnel. The airfoil section tested was obtained by rounding the midsection of a symmetrical double wedge with an arc tangent to the surface at 42.5 and 57.5 percent of the chord. This amount of rounding was believed sufficient to alleviate the adverse pressures resulting from the ridge of the double-wedge section. The resulting airfoil had a thickness of 4.23 percent of the chord. A section drawing of the model is shown in figure 1.

Lift and pitching-moment data were obtained by the use of the wind-tunnel balance system. The model completely spanned the 7-foot dimension of the tunnel between two 6-foot-diameter turntables (fig. 2); consequently, these results include the air forces acting on these turntables. Although the forces acting on the turntables affect the force and moment data obtained with the balance system, previous investigations have indicated that, with the exception of the drag, the turntable tare is negligible. The drag results presented were obtained from surveys of the wake behind the model. These surveys were limited to a small range of lift coefficients near minimum drag by the width of the survey rake available for the tests.

For some nose-flap deflections, severe buffeting of the model was encountered near maximum lift. When this occurred, it was not possible to determine the maximum lift coefficient.

The tests were made at a Reynolds number of 5.8 million and a Mach number of approximately 0.17. The results were corrected for constraint of the tunnel walls by the methods outlined in reference 2.

RESULTS AND DISCUSSION

The aerodynamic characteristics for the basic airfoil are presented in figure 3. The lift and pitching-moment characteristics of the airfoil for various deflections of the four nose flaps are presented in figure 4. The drag results for corresponding conditions are shown in figure 5. In figure 6 are the lift and moment results obtained with the 12-, 16-, and 20-percent-chord nose flaps deflected 30° and the 25-percent-chord trailing-edge flap deflected 50° and 60°. Presented in figures 7 and 8 is a summary of the variation of some of the characteristics with nose-flap chord. In these figures, the results for 5° and 15° nose-flap deflections have been extended to 25-percent chord, although test results were not obtained for those two deflections.

Lift Characteristics

The primary effect of increasing nose-flap chord on the lift characteristics of the airfoil was an increase in the angle of attack for zero lift. This shift in angle of attack was nearly linear in variation with both length of the nose flap and flap deflection. These results are summarized in figure 7. Also shown in figure 7 is the variation of maximum lift coefficient for various flap deflections with nose-flap chord. These results indicate a slight tendency toward increasing maximum lift coefficient with increasing flap chord. The results shown in figure 6 for the model with the 12-, 16-, and 20-percent-chord nose flaps at 30° and the 25-percent-chord trailing-edge flap at 50° and 60° indicate the same general effects of nose-flap-chord variation as were found with the trailing-edge flap undeflected.

It should be noted that the erratic force characteristics encountered previously with the 16-percent-chord flap deflected 35° (reference 1) were also found for the other flap-chord lengths investigated. As may be seen in figure 4(g), the discontinuities in the lift curves show no consistent variation with flap length for the range investigated.

Pitching-Moment Characteristics

Increasing the chord of the nose flap made the pitching moments generally more negative. (See fig. 4.) It should be noted in connection with the pitching-moment characteristics that the variation of pitching moment with lift at the stall was adversely affected by large nose-flap deflections as well as by increased flap chord. For small flap deflections, large negative moments were encountered at maximum lift. However, for larger flap deflections, the negative moment at the stall became less and with 30° nose-flap deflection there was little variation of pitching moment with lift near maximum lift. It is possible that for some applications such an effect would result in poor stalling characteristics of the airplane with nose flaps deflected.

Drag Characteristics

The variation of drag with lift for the various flap chords shown in figure 5 indicates little difference in minimum drag for a particular flap deflection in the low lift-coefficient range for any of the flaps. At the higher lift coefficients, some reduction in drag may be noted for the larger-chord flaps, although extensive results could not be obtained from the wake surveys. This advantage resulted primarily from the increase in lift coefficient for minimum drag with constant flap deflection obtained for the larger-chord flaps. The variation of lift coefficient for minimum drag with nose-flap chord is shown in figure 8.

CONCLUSIONS

Tests of a faired, double-wedge airfoil section with nose flaps having chords of 12-, 16-, 20-, and 25-percent chord indicated the following conclusions:

1. The primary effect of variation of nose-flap chord upon the lift characteristics was an increase in the angle of attack for zero lift with increased flap chord. Little variation of maximum lift with flap chord was obtained.

2. The principal effect of increased flap chord on the pitching moments was to make these moments generally more negative. Large deflections of the nose flap and increased flap chord had an adverse

effect on the variation of pitching moment with the lift at the stall.

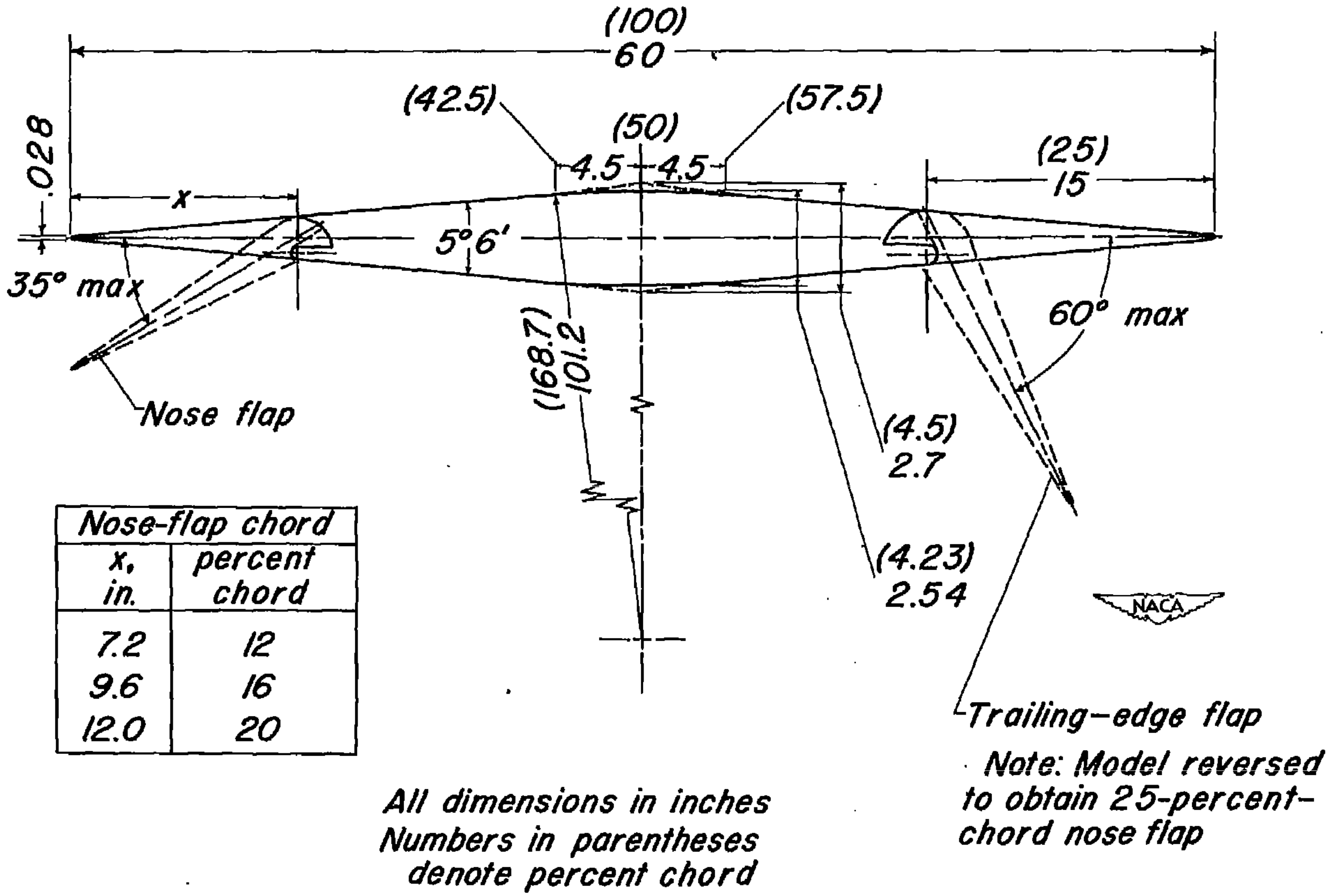
3. With constant flap deflection, the lift coefficient for minimum drag increased with increased flap chord. The net result was that the larger-chord flaps produced the least drag at the higher lift coefficients.

Ames Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Moffett Field, Calif., Nov. 17, 1949.

REFERENCES

1. Rose, Leonard M., and Altman, John M.: Low-Speed Experimental Investigation of a Thin, Faired, Double-Wedge Airfoil Section with Nose and Trailing-Edge Flaps. NACA TN 1934, 1949.

2. Allen H. Julian, and Vincenti, Walter G.: Wall Interference in a Two-Dimensional-Flow Wind Tunnel with Consideration of the Effects of Compressibility. NACA Rep. 782, 1945.



Nose-flap chord	
x, in.	percent chord
7.2	12
9.6	16
12.0	20

Figure 1.- The faired, double-wedge airfoil with nose flaps and trailing-edge flaps.

Figure 2.- The faired, double-wedge airfoil model installed in the wind tunnel.

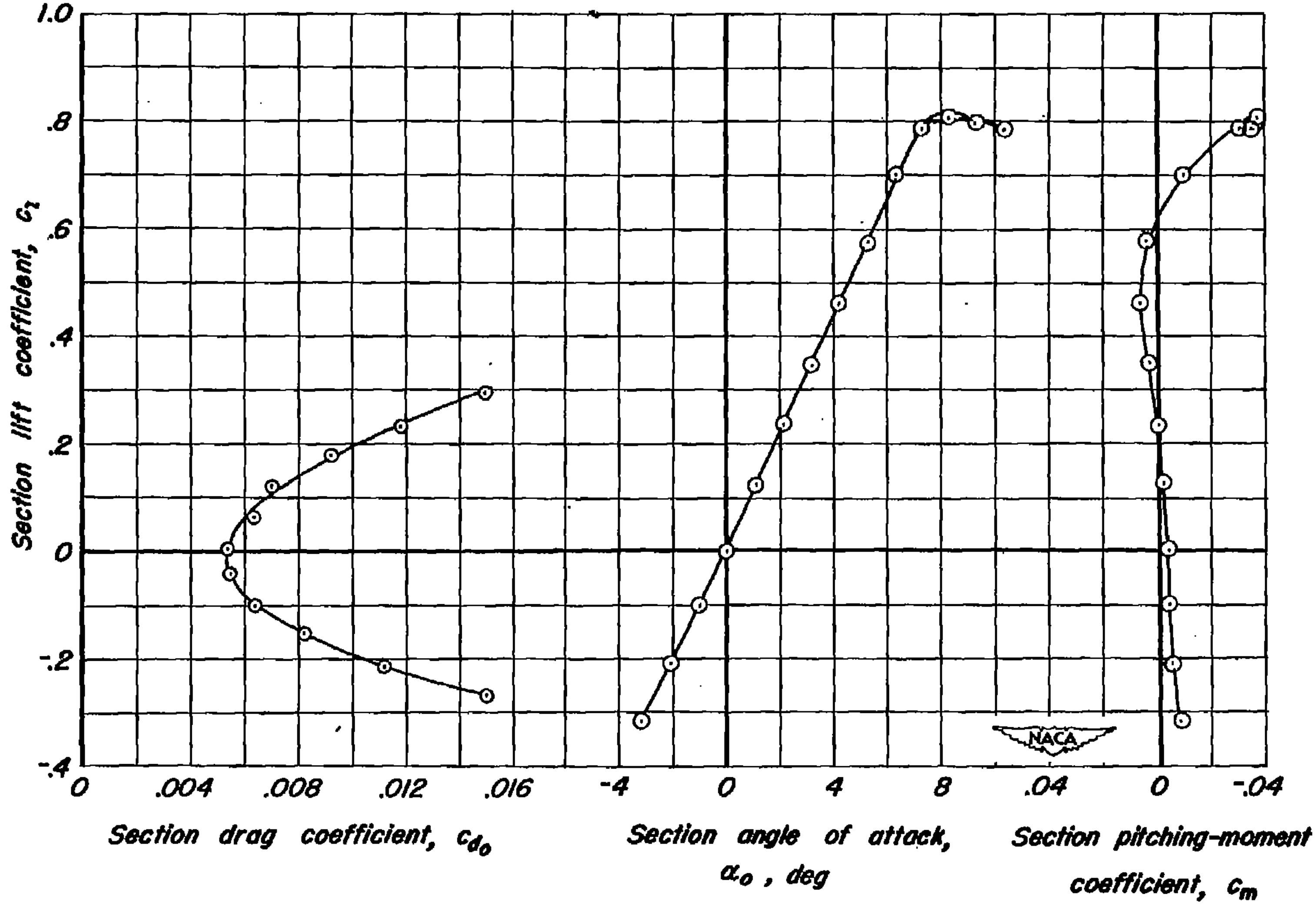
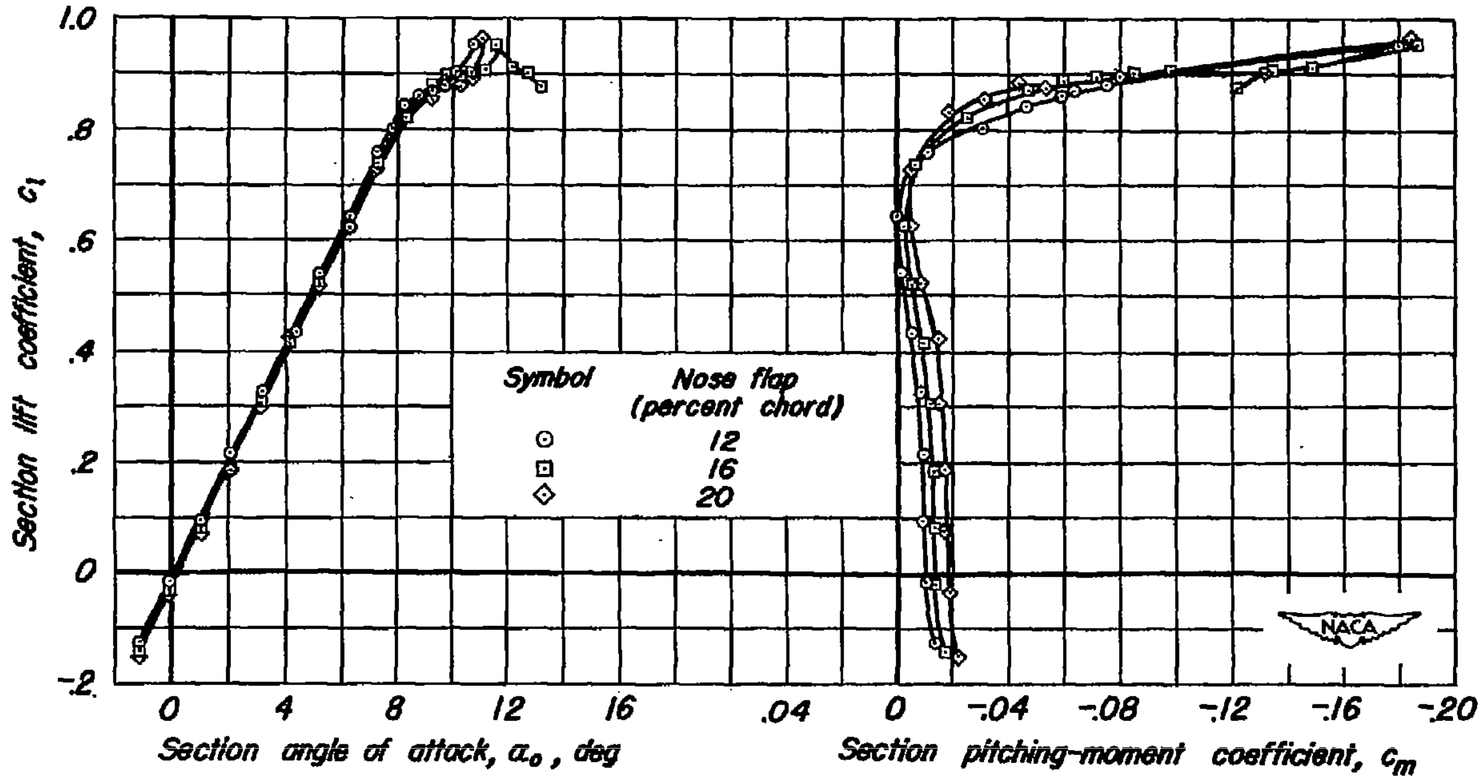
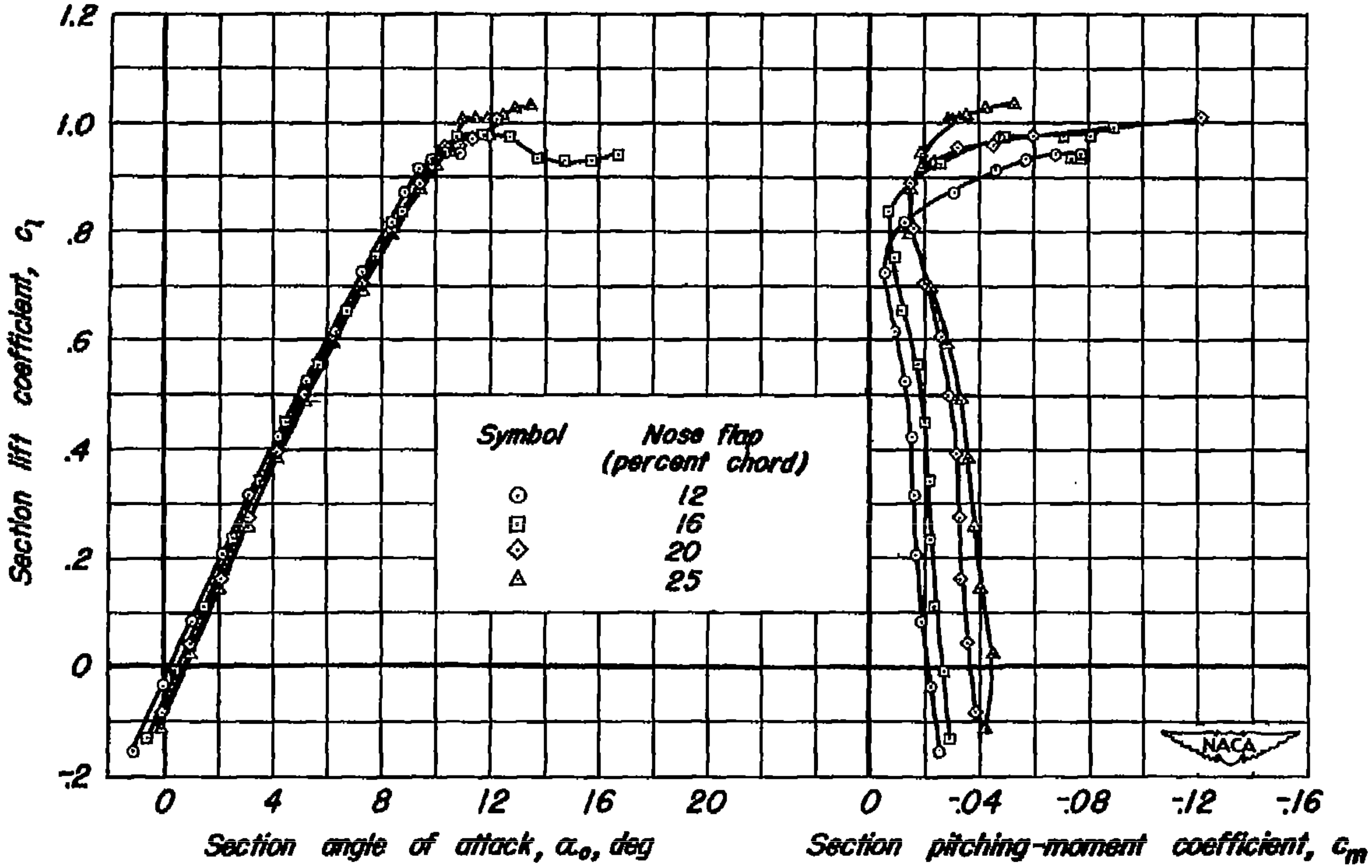


Figure 3.– Section lift, drag, and pitching-moment characteristics for the basic airfoil.



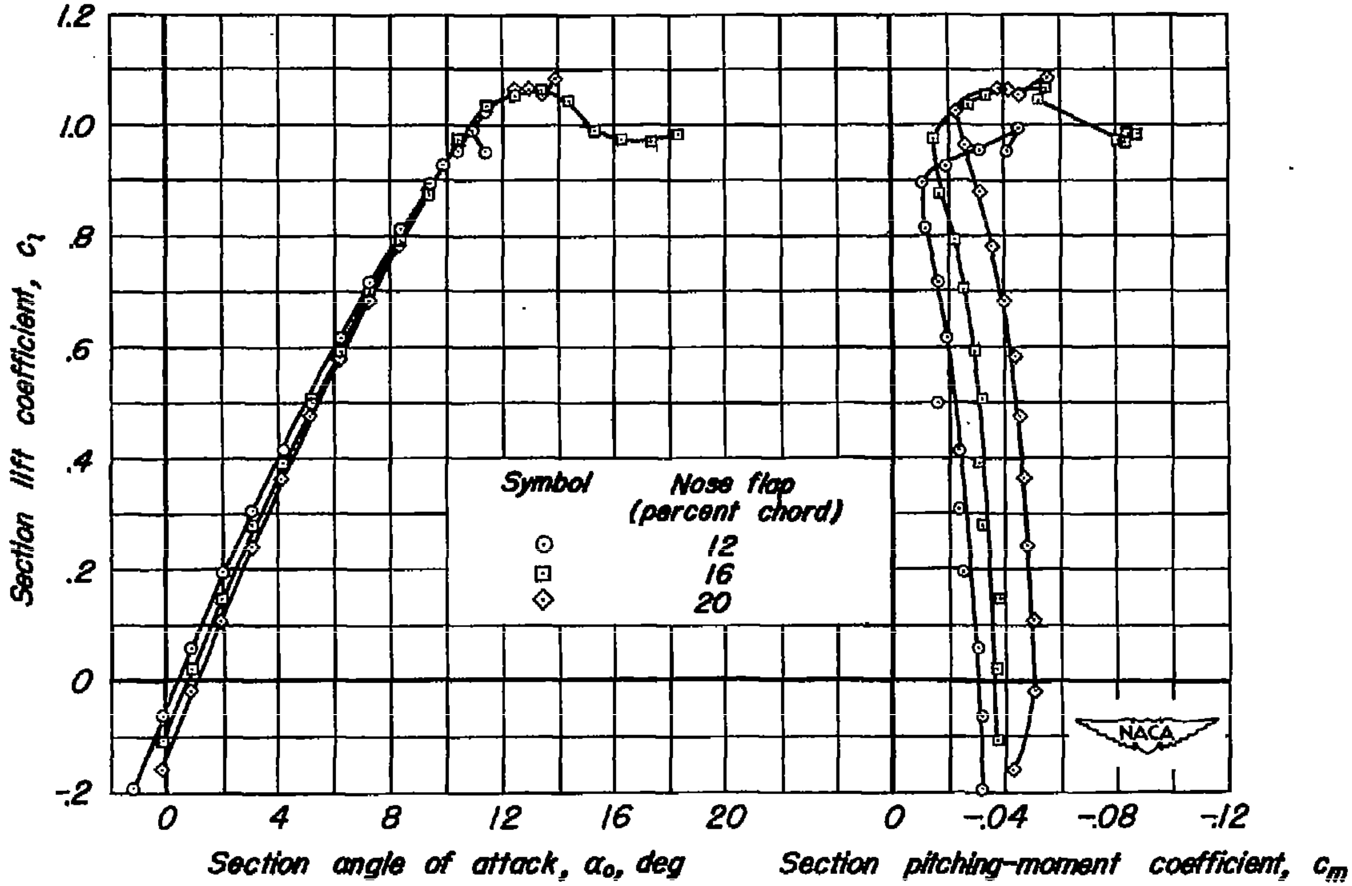
(a) Nose flap deflected 5°.

Figure 4.—The effect of nose-flap chord on section lift and pitching-moment characteristics. Trailing-edge flap undeflected.



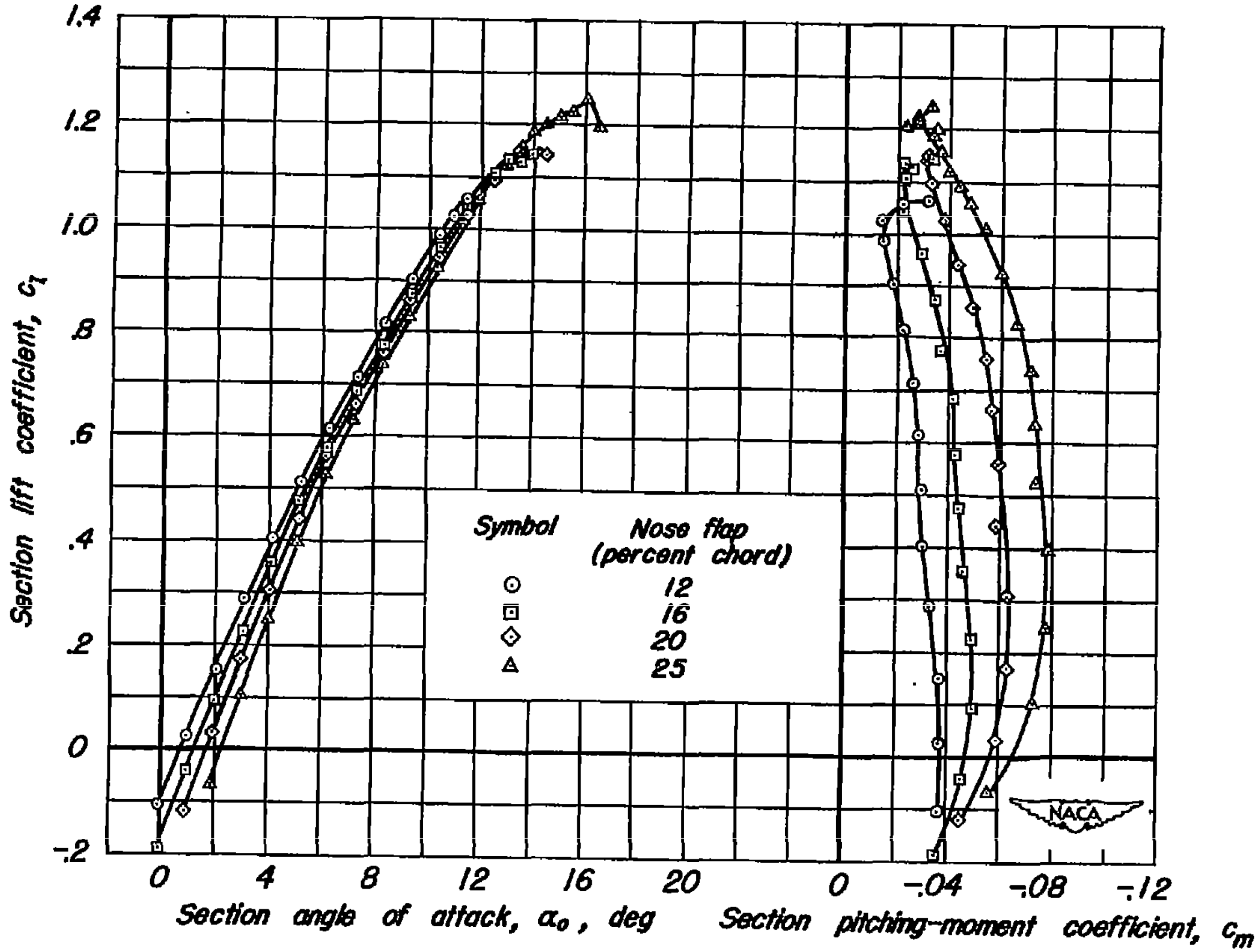
(b) Nose flap deflected 10°.

Figure 4.—Continued.



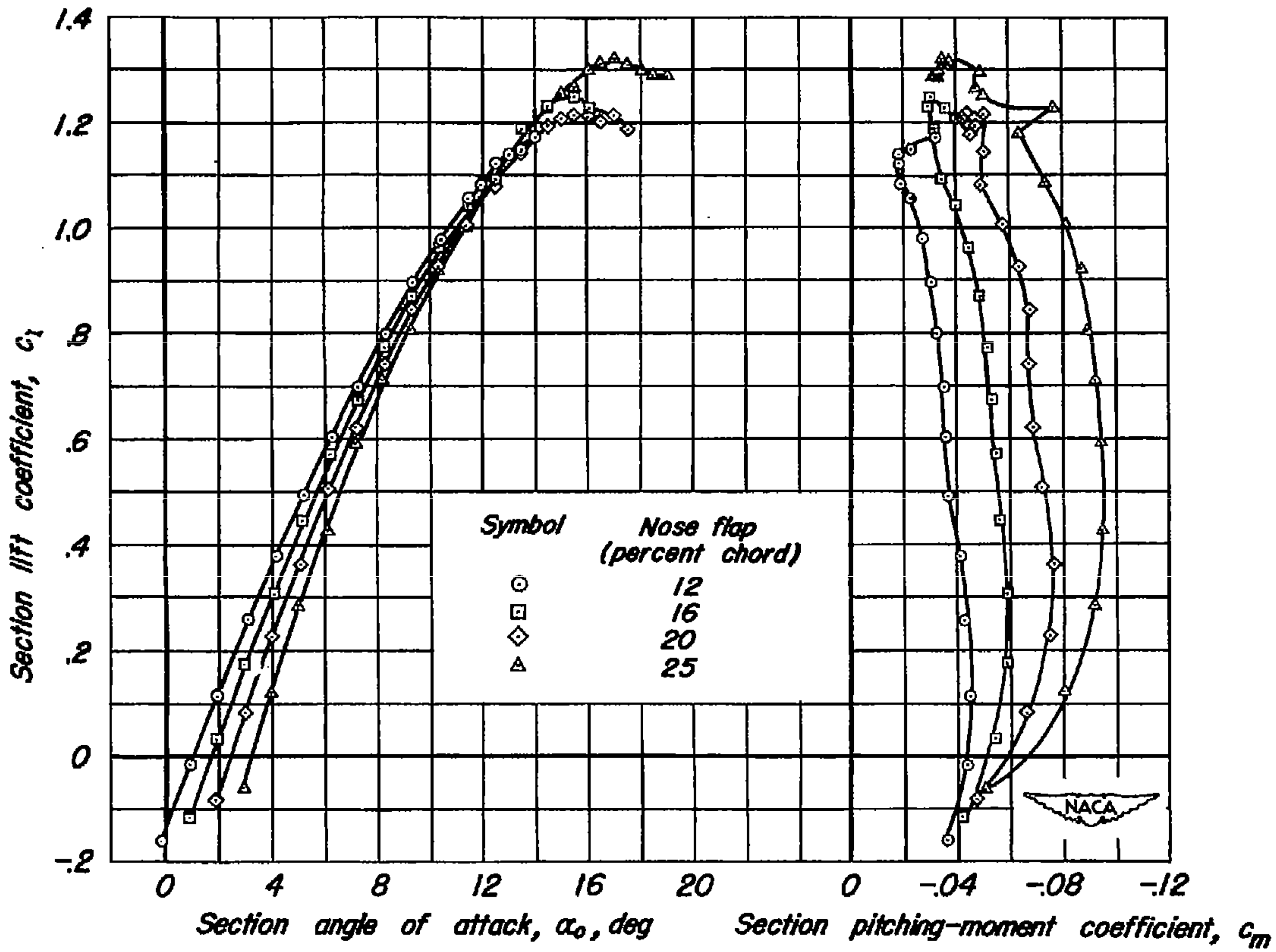
(c) Nose flap deflected 15°.

Figure 4.—Continued.



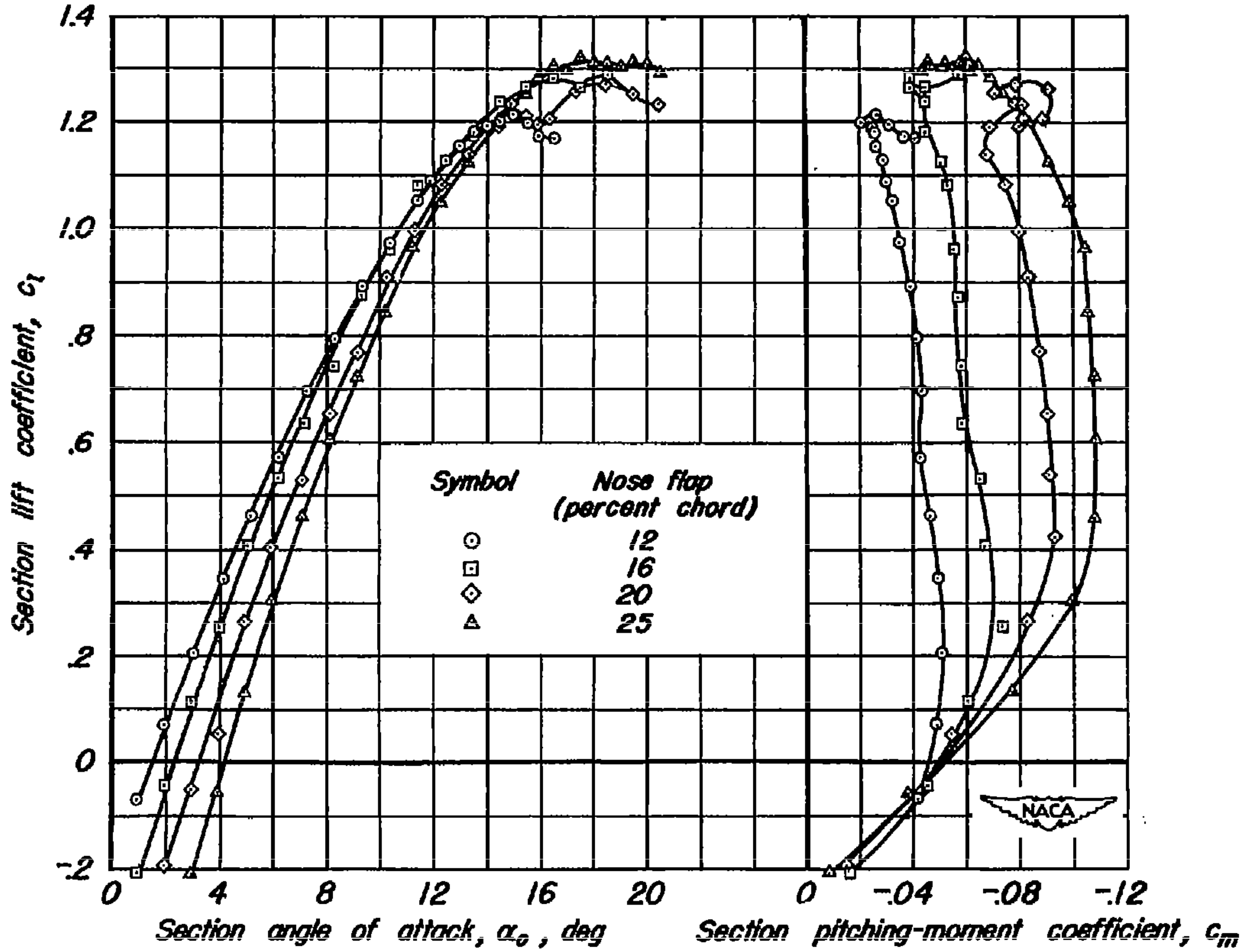
(d) Nose flap deflected 20°.

Figure 4.—Continued.



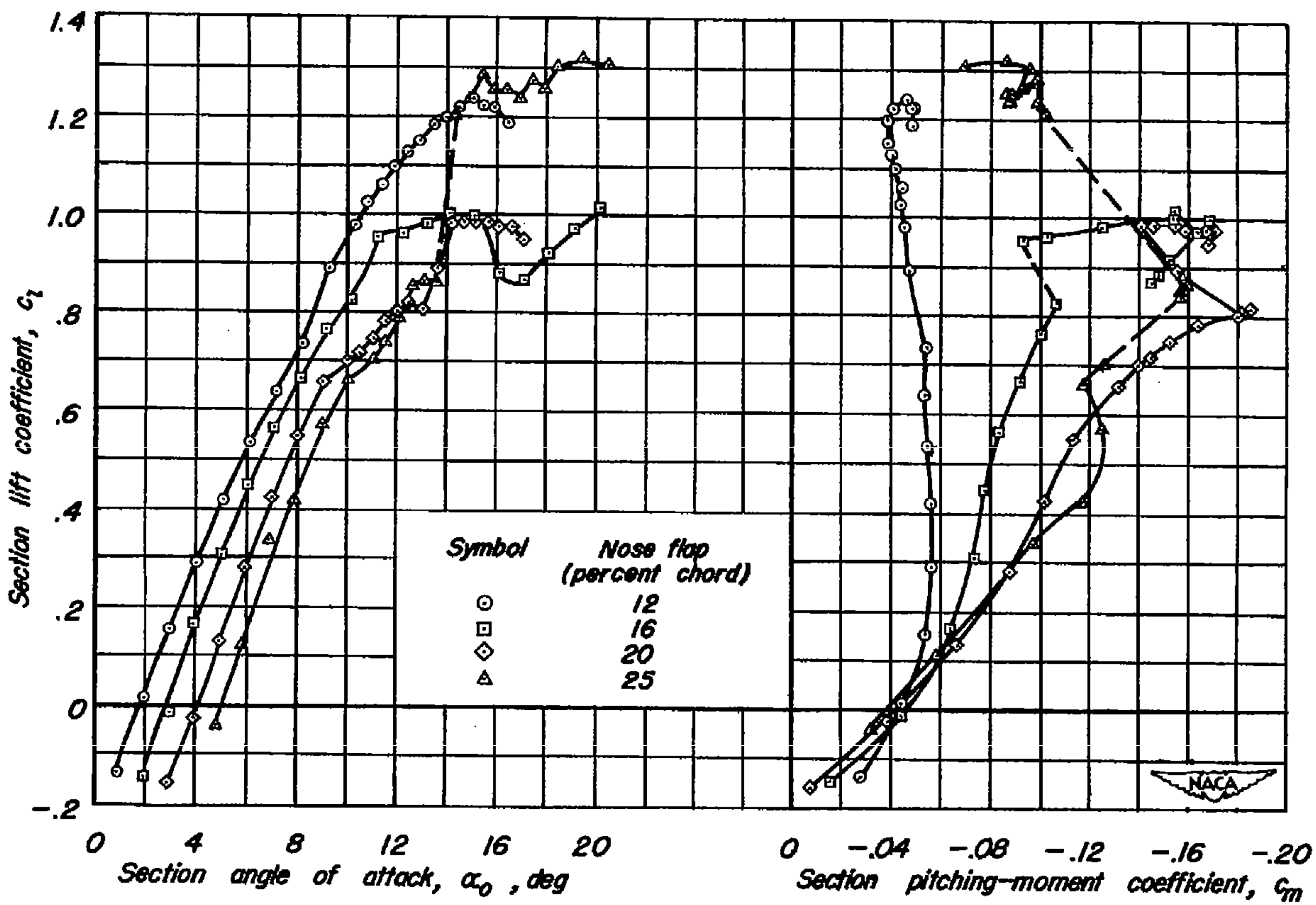
(e) Nose flap deflected 25°.

Figure 4.—Continued.



(f) Nose flap deflected 30°.

Figure 4.—Continued.



(g) Nose flap deflected 35°.

Figure 4.—Concluded.

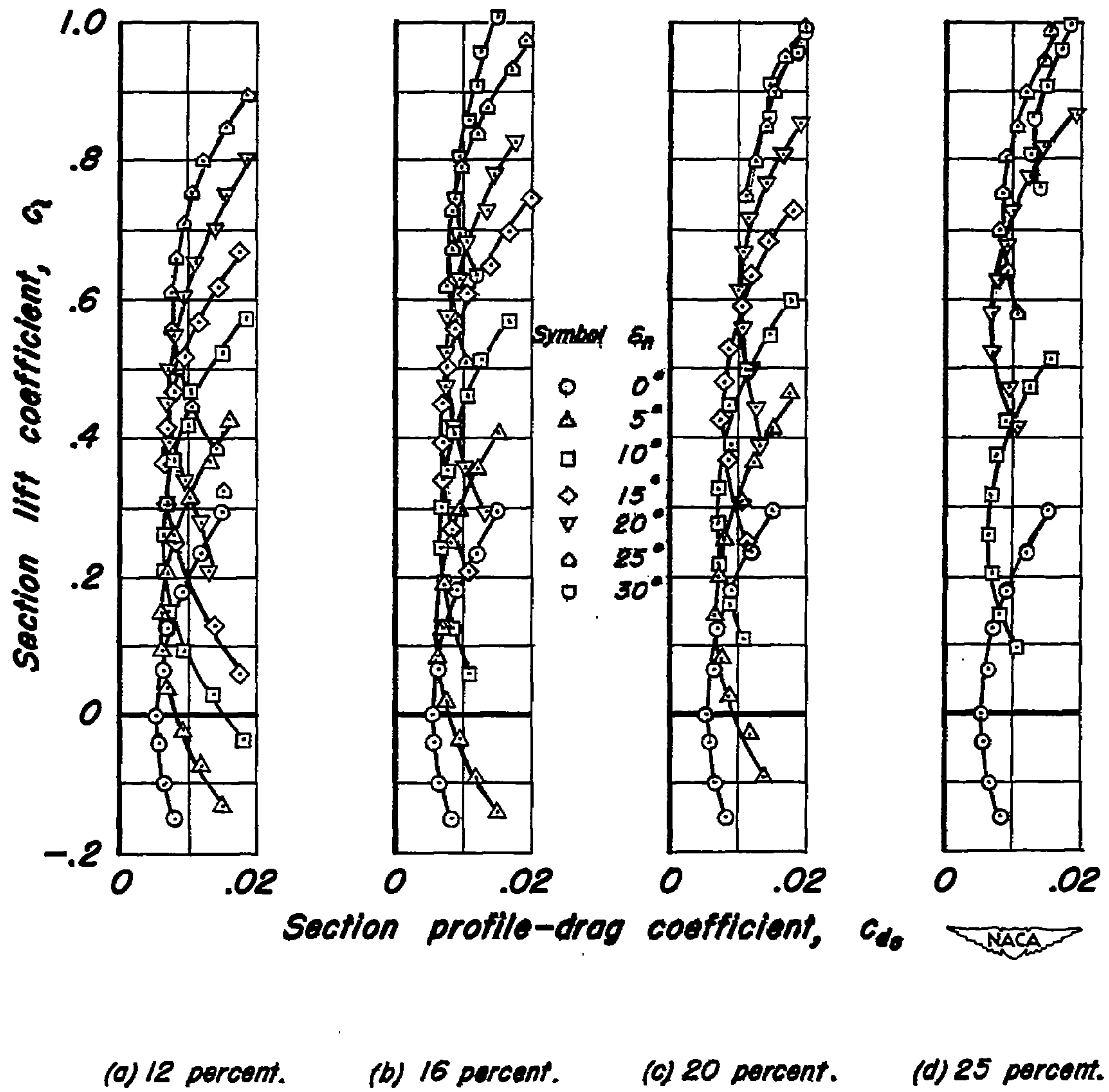


Figure 5.—Section profile-drag characteristics for the various nose-flap chords.

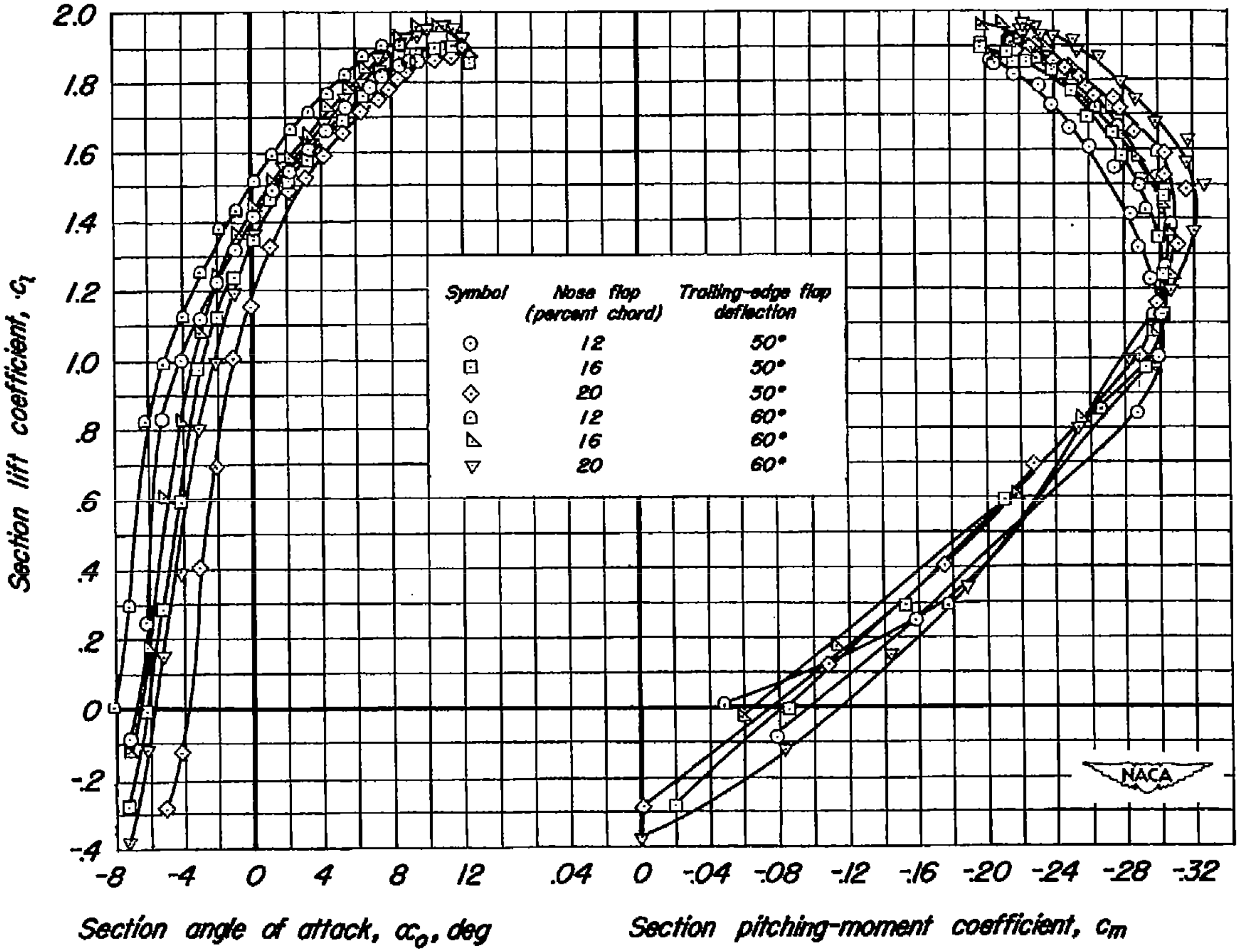
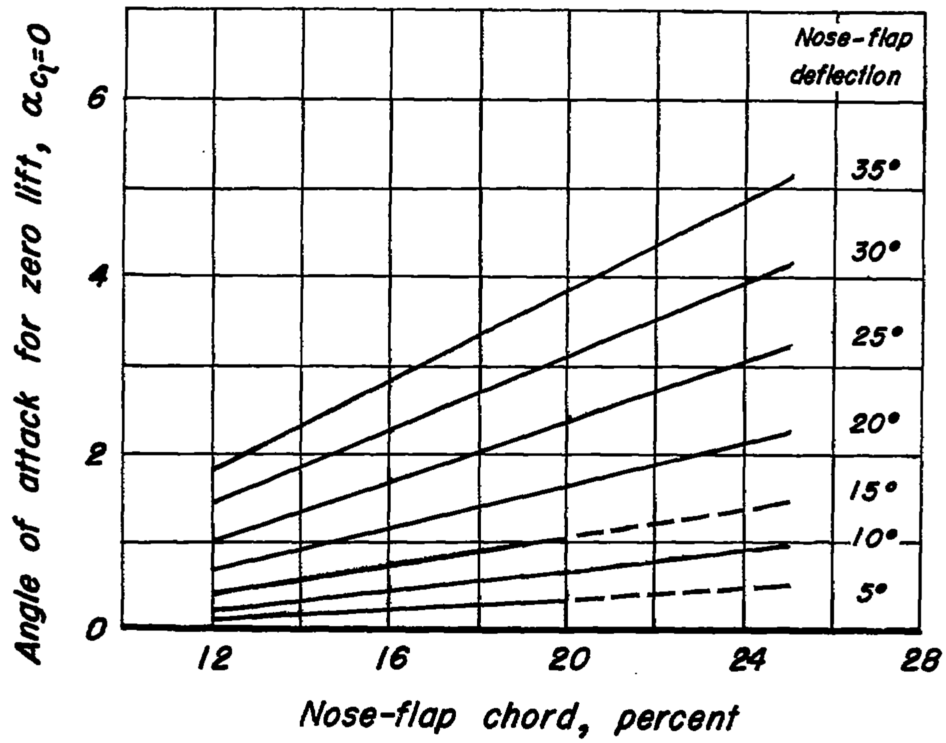


Figure 6.—The effect of nose-flap chord on the lift and pitching-moment characteristics with the trailing-edge flap deflected. Nose flap deflected 30°.



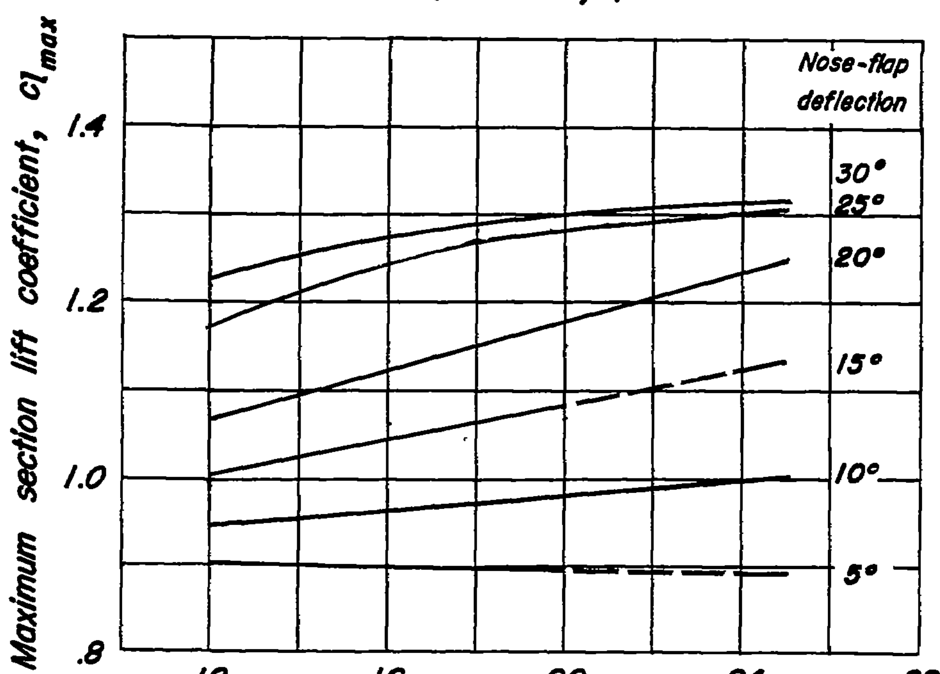


Figure 7.—The effect of nose-flap chord on the angle of attack for zero lift and on the maximum lift.

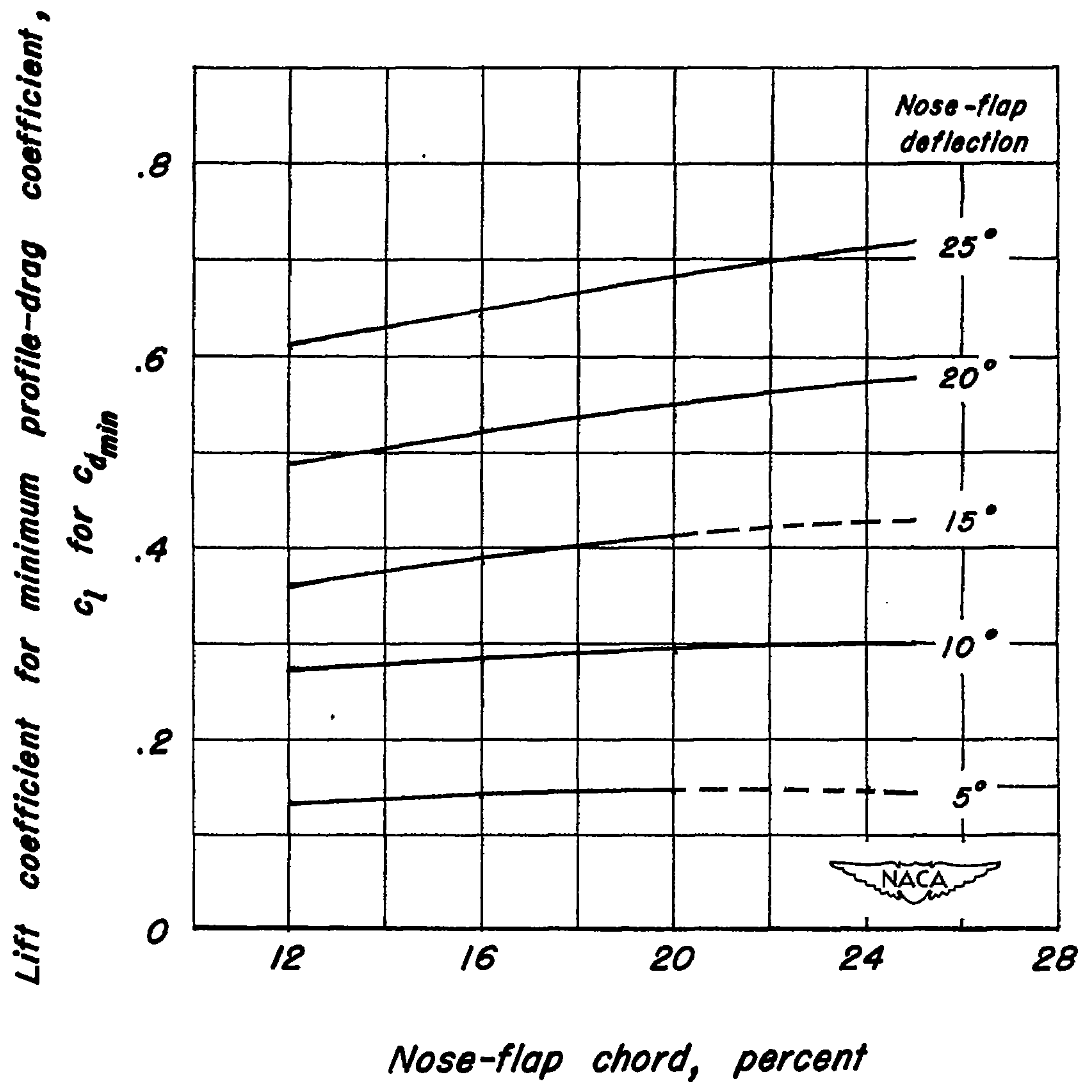


Figure 8.– The effect of nose-flap chord on the lift coefficient for minimum drag.